

Solar Farm Analytics

Automated Machine Learning Deployed at Scale

Paul Venditti, SAS Advisory Industry Consultant
Steve Enck, SAS Senior Manager Consulting



Presenters Background



Advisory Industry Consultant

GE Power

- Industrial Apparatus Sales Engineer
- Six Sigma Black Belt

GE Research

- Systems Engineer (Remote Services)
- Operations Research (Digital Twins)

SAS

- Industry Consultant (Partners/Ecosystem)



Sr. Manager IoT Consulting

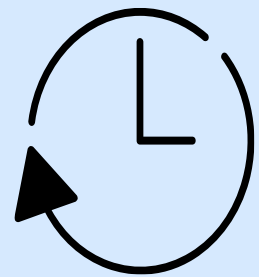
SAS

- 20+ years analytical consulting experience
- Delivered real-time analytics projects related to:
 - HVAC analytics
 - Flood prediction
 - Manufacturing optimization
 - Solar farm monitoring
- Development of automated approach to simplify model training and deployment

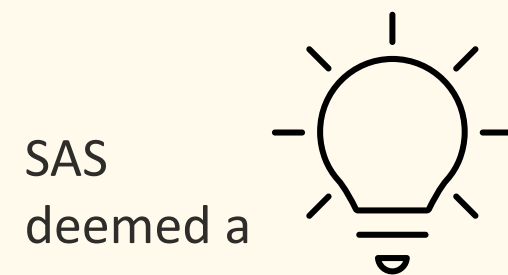
SAS Introduction

Our Resume

#1 Market Leader in
**AI & ADVANCED
ANALYTICS**



47
Years of
**BUSINESS
ANALYTICS**



SAS
deemed a
**World's
Most
Innovative
Company**
(Fast Company
March 2021)

Our Customers

80,000+

Customer sites in 150 countries



88 of the top
100

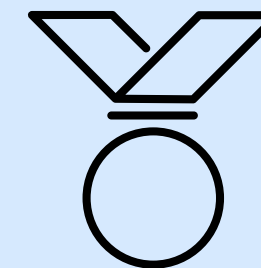
Companies on the GLOBAL LIST
ARE SAS CUSTOMERS or their
affiliates

**FORTUNE
500**

Our Peers

8 YEARS RUNNING

Only vendor named leader
in Gartner's Magic Quadrant
for Data Science and Machine Learning Platforms



SAS recognized
as leader in
more than 30
vendor ranking
reports in 2021

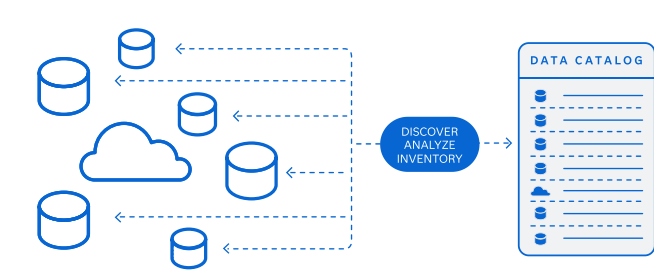
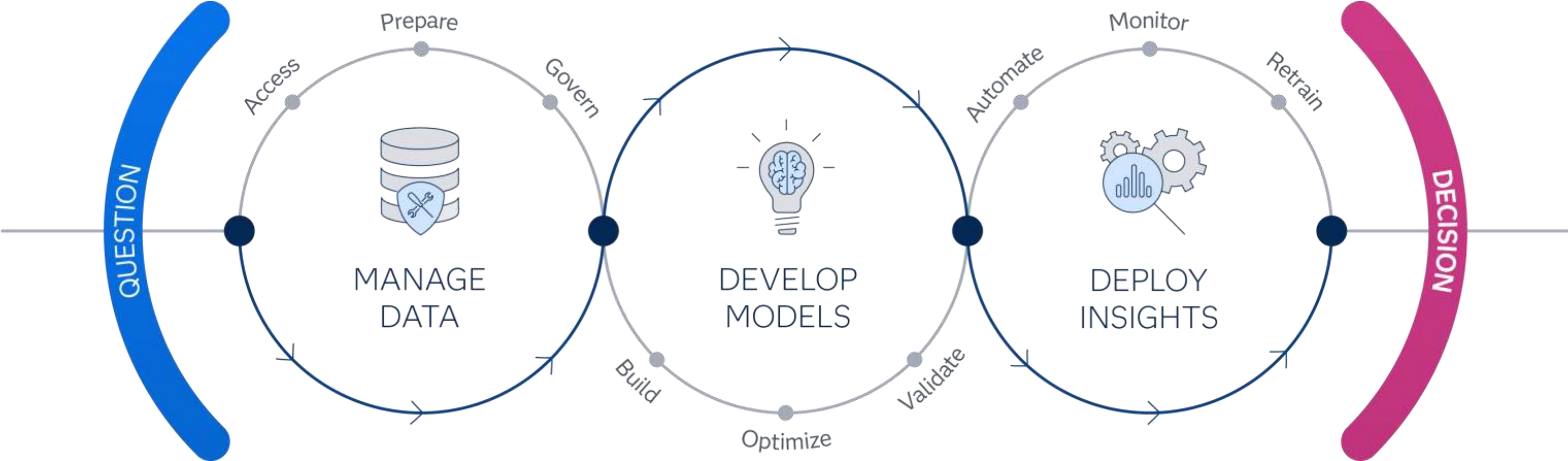
Utility Scale Solar
Growth Rate Up

50%

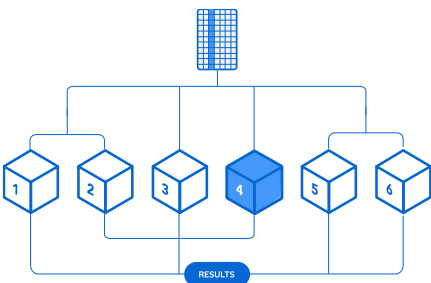
Machine Learning
makes it possible to
accurately monitor
optimal performance
for ALL assets and
controllable variables



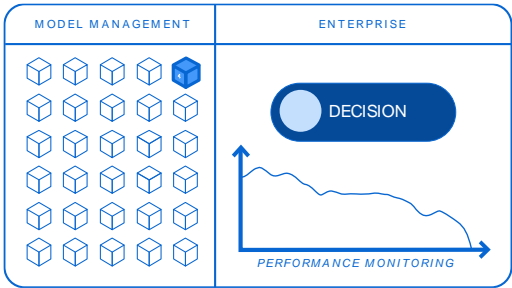
SAS Viya



Any Data, Any Where



Model Development & Automation



Insights/Decisions at Scale

AutoML for IoT

Cross Domain Application

**Extensible, Cross
Industry
Framework**

Smart Building
Predictive Maintenance
& Energy Efficiency



SAS Campus



(Cities, Universities)

Manufacturing
Operation Improvement
Yield & Safety



Georgia Pacific

Smart City
Situational Awareness &
Flood Prediction



Town of Cary

Solar Farm
Predictive Maintenance
& Energy Efficiency



SAS Campus



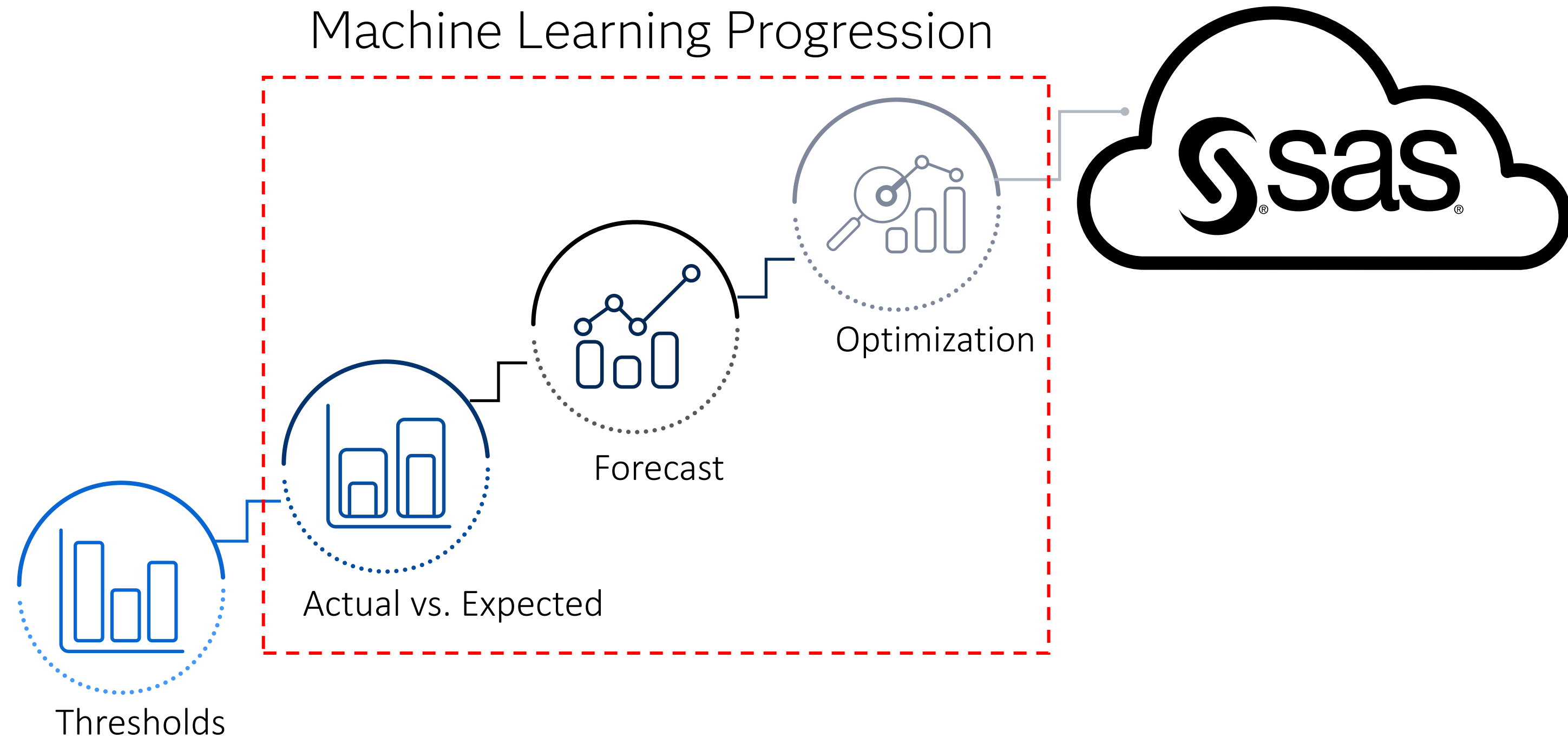
(DEPCOM Power)

Description

- Transform thousands of seemingly disparate raw sensor readings
- Integrate hundreds of ML models to monitor operation and predict future outcomes
- Deploy meaningful alerts to your end users and are designed to offer immediate value
- Highlight potential root causes
- Configure based on simple inputs that a subject matter expert could provide

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Logical Progression of Analytics Complexity





**Harvard
Business
Review**

AI And Machine Learning

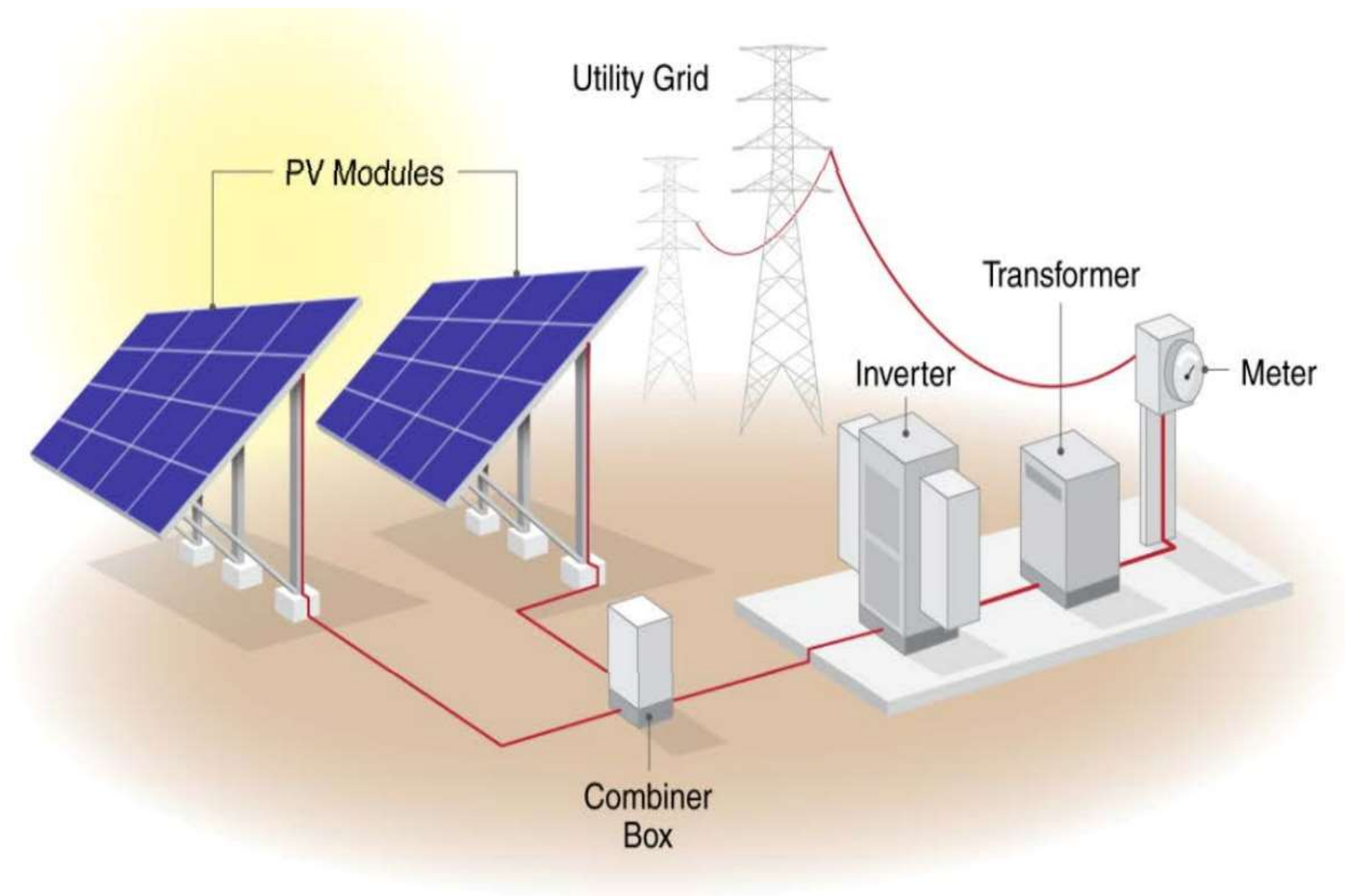
The AI Hype Cycle Is Distracting Companies

by Eric Siegel

June 02, 2023



Illustration by Skizzomat



Source: NREL

Solar Farm



Irradiance: 742.8 W/m²
Power: 235.5 kW
Expected Power: 282.5 kW
% of Expected: 83%

Inverter



Input DC Power: 247.9 kW
Output AC Power: 235.5 kW
Temperature: 59.9 C
Conversion Efficiency: 95%

Combiner Box



Temperature: 35 C


Solar Panels





Current 1: 24.75 A (25.7 expected = 96%)
Current 2: 11.75 A (12.2 expected = 96%)
Current 3: 6.45 A (10.5 expected = 61%)
Angle: 32 degrees (optimal 41 degrees)

The Vision

Integrating Machine Learning Models Throughout Everyday Operation

- ML Models Deployed to Monitor...
 - Key performance metrics
 - e.g., Energy generation from each asset in the solar farm

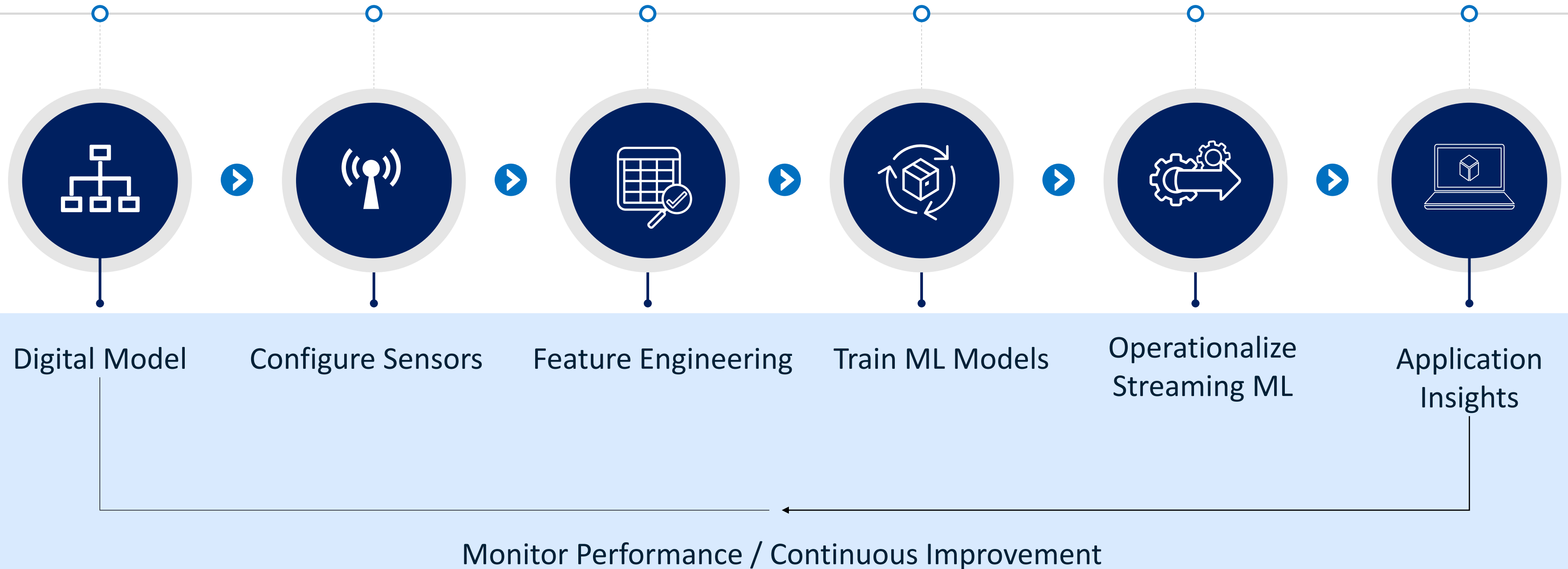
Continuous monitoring for unexpected decreases in energy generation for each asset
 - Key settings that we can change
 - e.g., solar panel angle

Ongoing review of settings given current conditions
 - Trends/forecasts in measurements that are critical to operation
 - e.g., temperatures

Proactively anticipate potential issues before they impact operation

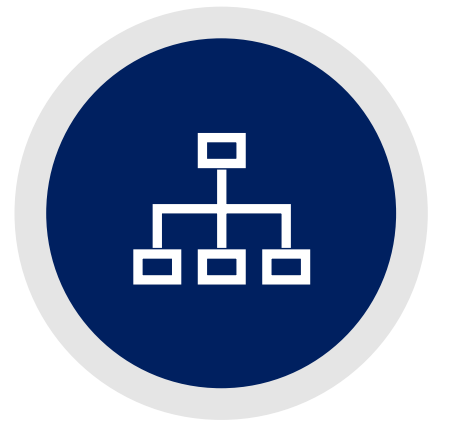
AutoML for IoT – Solar Farm Use Case

A Solution Accelerator for Rapidly Developing & Deploying Streaming Analytics



AutoML for IoT

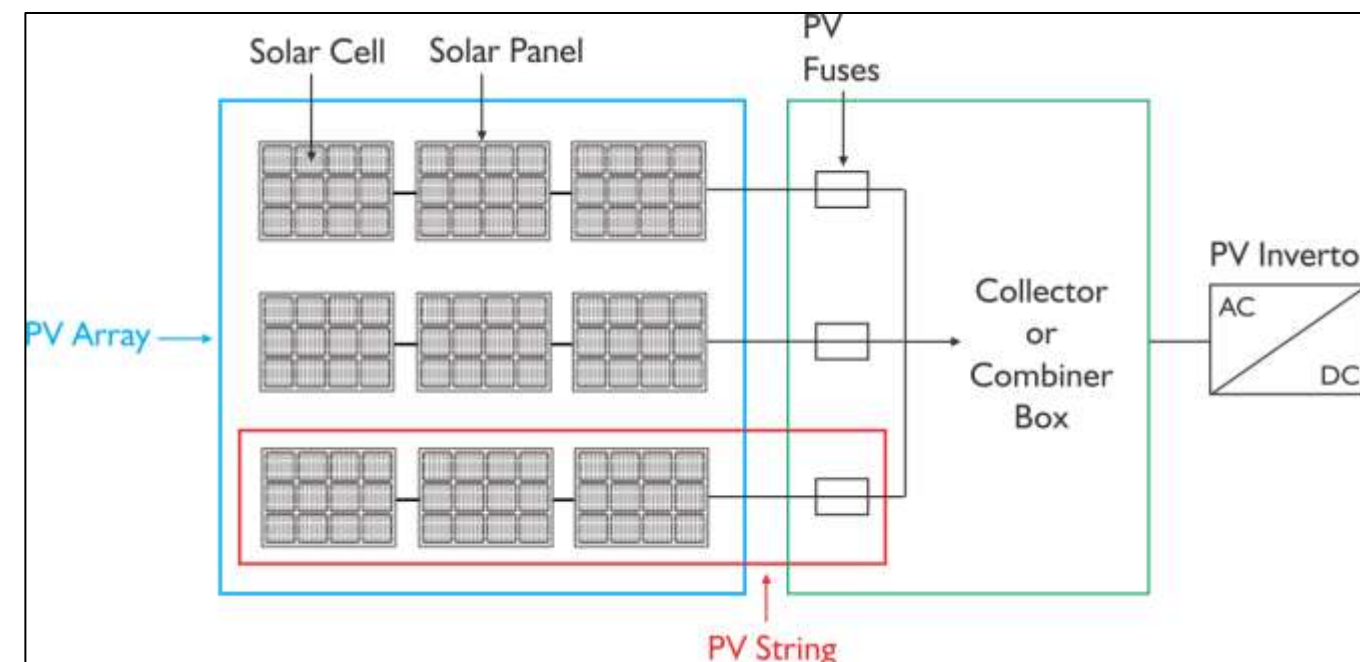
Step 1 – Digital Model Representation



Overhead View

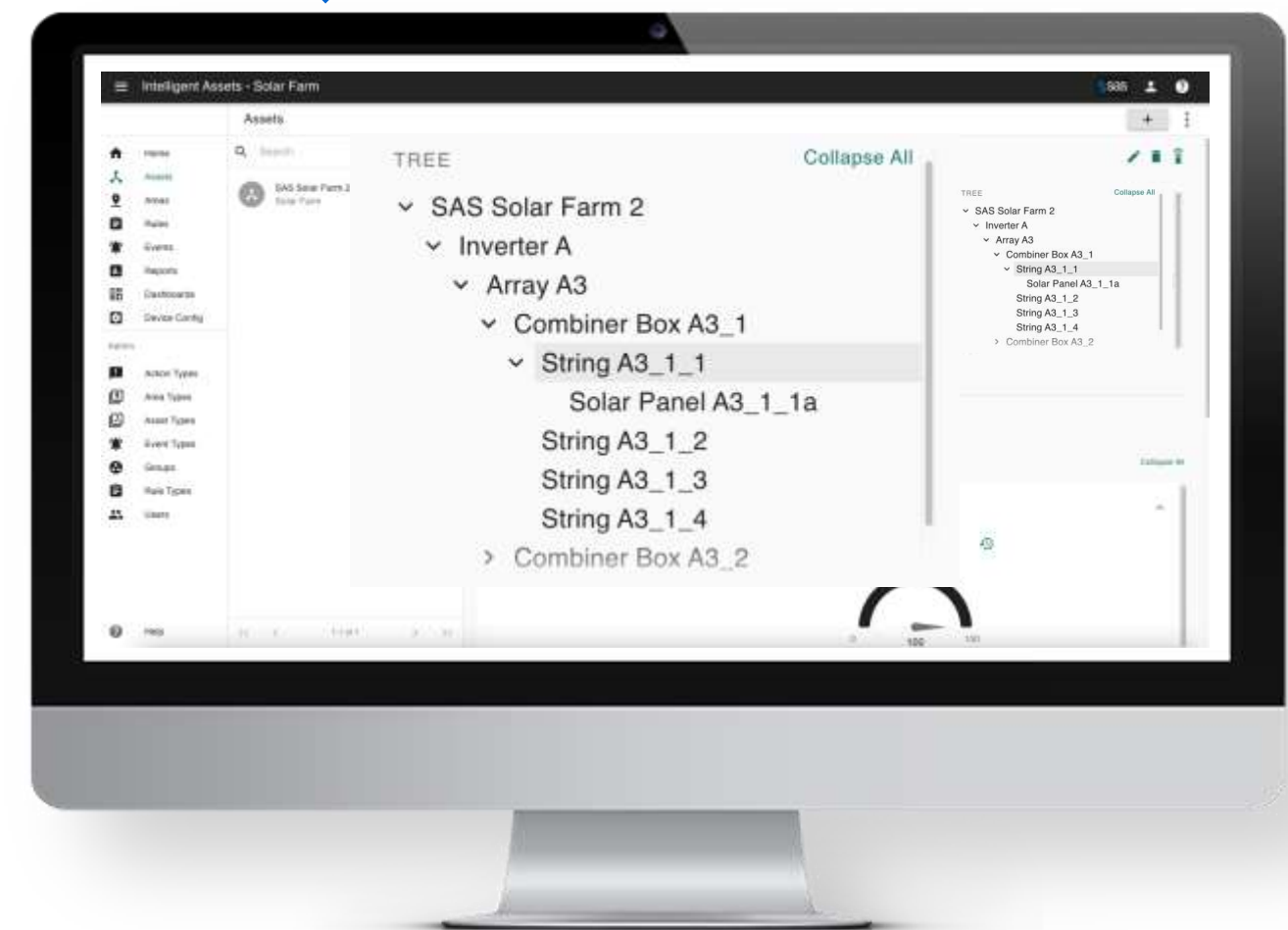


Asset Structure



Source:
<https://www.swe-check.com.au/editorials/solar-pv-circuit-protection-guide.php>

Digital Map



AutoML for IoT

Step 2 – Connect to real-time sensors



SAS® Event Stream Processing Studio

Projects ESP Servers | solarFarm_historical x Test: solarFarm_historical x

Status: Started Run Test Stop Publish Performance ESP server: sas-viya

Continuous query: cq1 Currently retained events: 0 Show formatted fields

Drag a column header and drop it here to group by that column

Opcode	key1	msr_timestamp	assetID	attributeID	value
Insert	6061	2023-04-01T06:39:03.9...	STRNG_B1_3_2	current_A	0.00000000
Insert	6060	2023-04-01T06:39:03.9...	STRNG_B1_3_1	current_A	0.00000000
Insert	6059	2023-04-01T06:39:03.9...	STRNG_B1_2_4	current_A	0.13000000
Insert	6058	2023-04-01T06:39:03.9...	STRNG_B1_2_3	current_A	0.08000000
Insert	6057	2023-04-01T06:39:03.9...	STRNG_B1_2_2	current_A	0.41000000
Insert	6056	2023-04-01T06:39:03.9...	STRNG_B1_2_1	current_A	0.30000000
Insert	6055	2023-04-01T06:39:03.9...	STRNG_B1_1_4	current_A	0.20000000
Insert	6054	2023-04-01T06:39:03.9...	STRNG_B1_1_3	current_A	0.30000000
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Insert	6051	2023-04-01T06:39:03.9...	STRNG_A4_4_4	current_A	0.00000000
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Insert	6049	2023-04-01T06:39:03.9...	STRNG_A4_4_2	current_A	0.14000000
Insert	6048	2023-04-01T06:39:03.9...	STRNG_A4_4_1	current_A	0.18000000

1 - 25 of 1,000 items

Real-time raw data
dashboard



AutoML for IoT

Step 3 – Feature Engineering



SAS® Event Stream Processing Studio - Test

Projects ESP Servers slrfm_combinerBox_re... Test: slrfm_combinerB...

Status: Started

Run Test Stop Publish ESP server: sas-viya

Window

source_C01_w... source_C01_w... source_C01_w... IoTHubSolarFarm ParseloTHubSo... SolarFarmData measurement_... node_package... hierarchicalDat... union_data_so... source_addcon... addcontext_for... source_history... source_history... source_output... source_output... source_output... combinerBox_s... combinerBox_s... combinerBox_... combinerBox_... combinerBox_... union_combin... combinerBox_t... combinerBox_... module10

Continuous query: cq1 Currently retained events: 0

Drag a column header and drop it here to group by that column

Solar Farm Metrics Inverter Metric Combiner Box Metrics

deviceType	deviceLabel	msr_date	msr_time	wth_cloudcover	wth_humidity	irradiance_poa_mj	INVRTR_dc_voltag	CMBX_temperatur	current_thisBox
combinerBox	Combiner Box A2...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	46.000000	147.600000
combinerBox	Combiner Box A4...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	43.000000	204.000000
combinerBox	Combiner Box B1...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	377.600000	0.000000	0.000000
combinerBox	Combiner Box A2...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	55.000000	196.670000
combinerBox	Combiner Box A3...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	49.000000	131.930000
combinerBox	Combiner Box A4...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	0.000000	149.470000
combinerBox	Combiner Box B1...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	377.600000	42.000000	199.320000
combinerBox	Combiner Box A3...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	53.000000	152.490000
combinerBox	Combiner Box B1...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	377.600000	46.000000	195.650000
combinerBox	Combiner Box B4...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	377.600000	43.000000	136.720000
combinerBox	Combiner Box A4...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	39.000000	119.650000
combinerBox	Combiner Box B1...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	377.600000	42.000000	169.130000
combinerBox	Combiner Box A4...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	362.800000	56.000000	153.880000
combinerBox	Combiner Box B1...	22,901.000000	45,900.000000	25.000000	38.000000	898.080000	377.600000	42.000000	176.710000
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1 - 15 of 15 rows

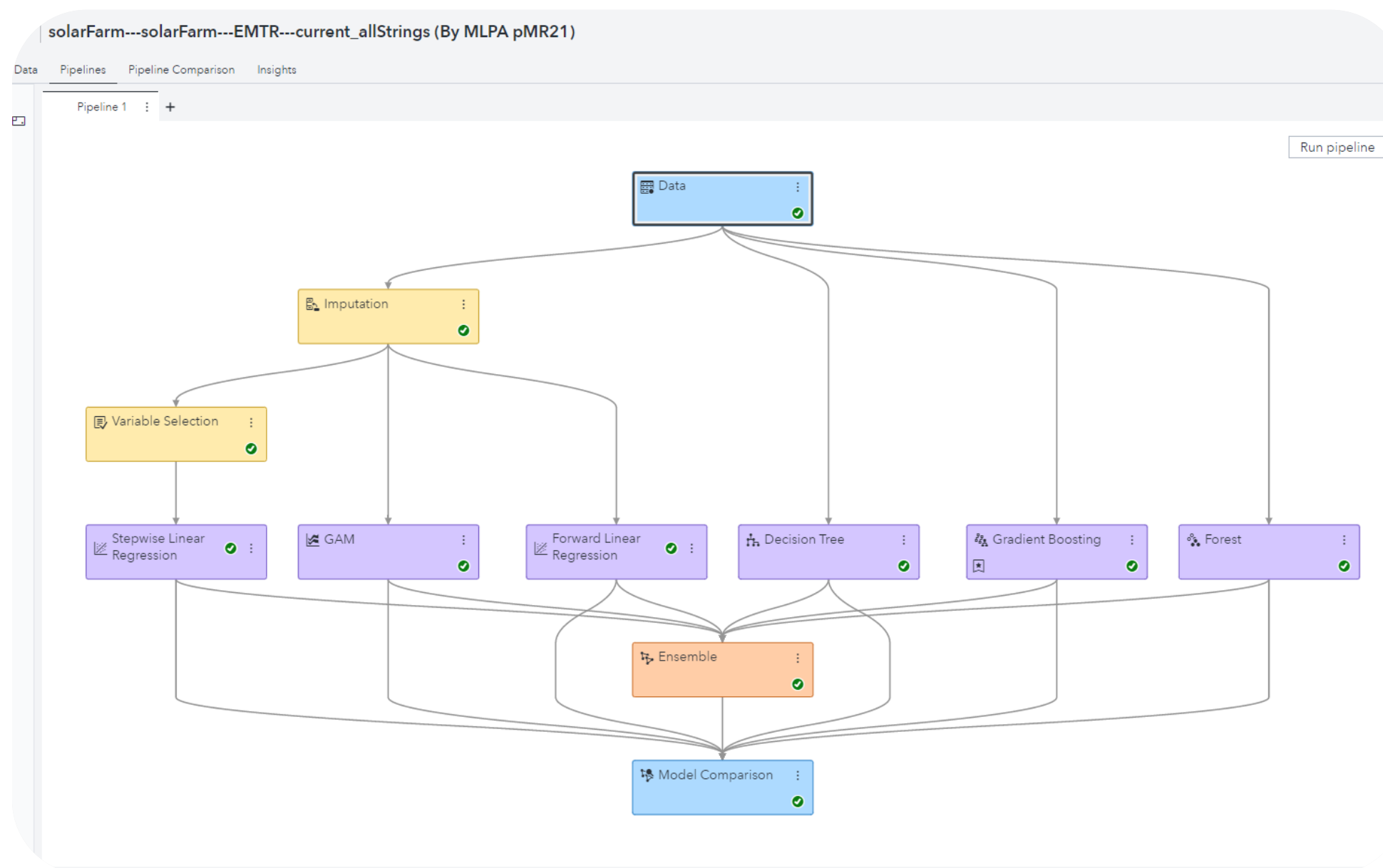
sas

AutoML for IoT

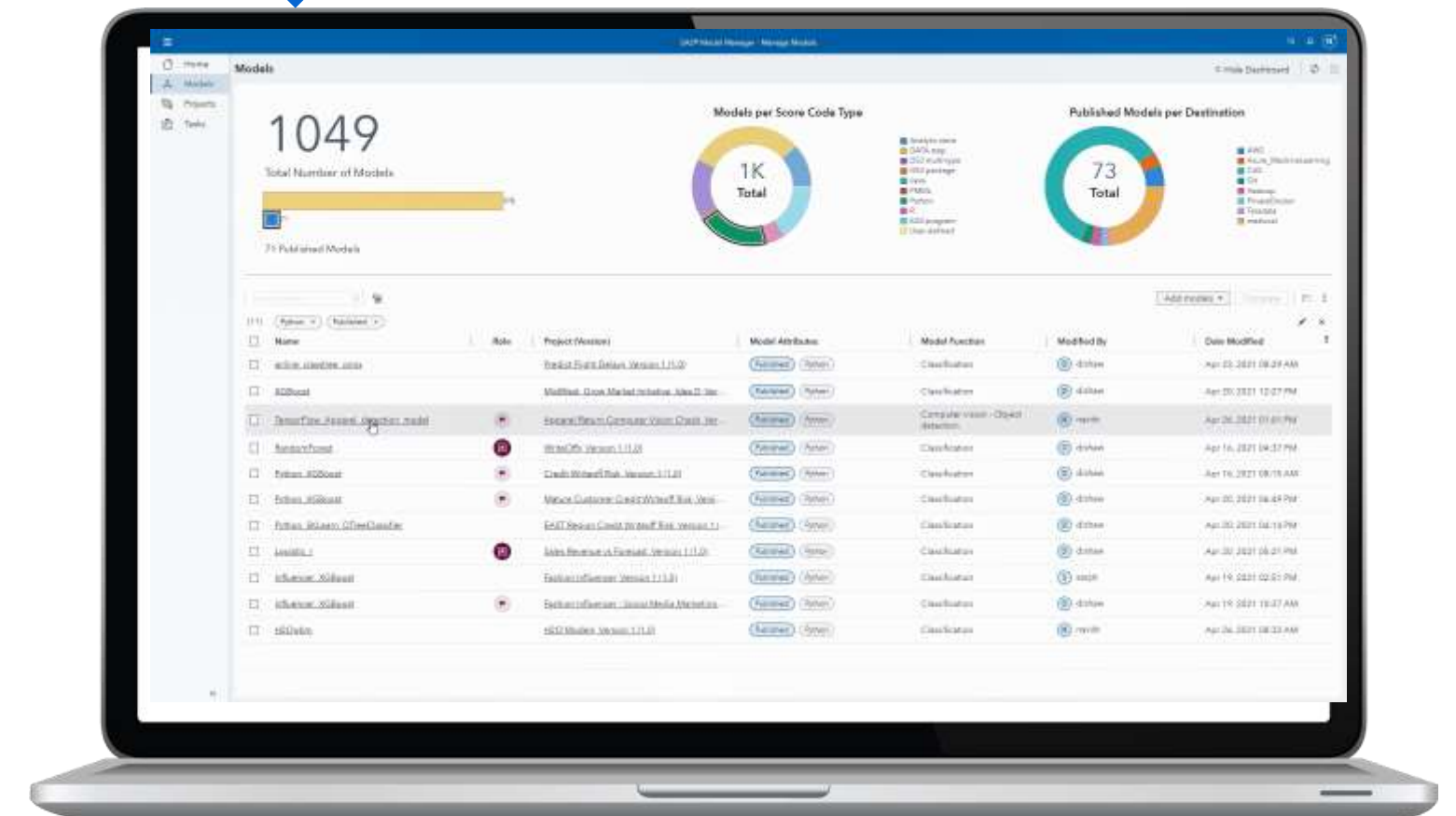
Step 4 – Train ML Models and Register in Model Management



Train Models using
Machine Learning Pipeline Automation

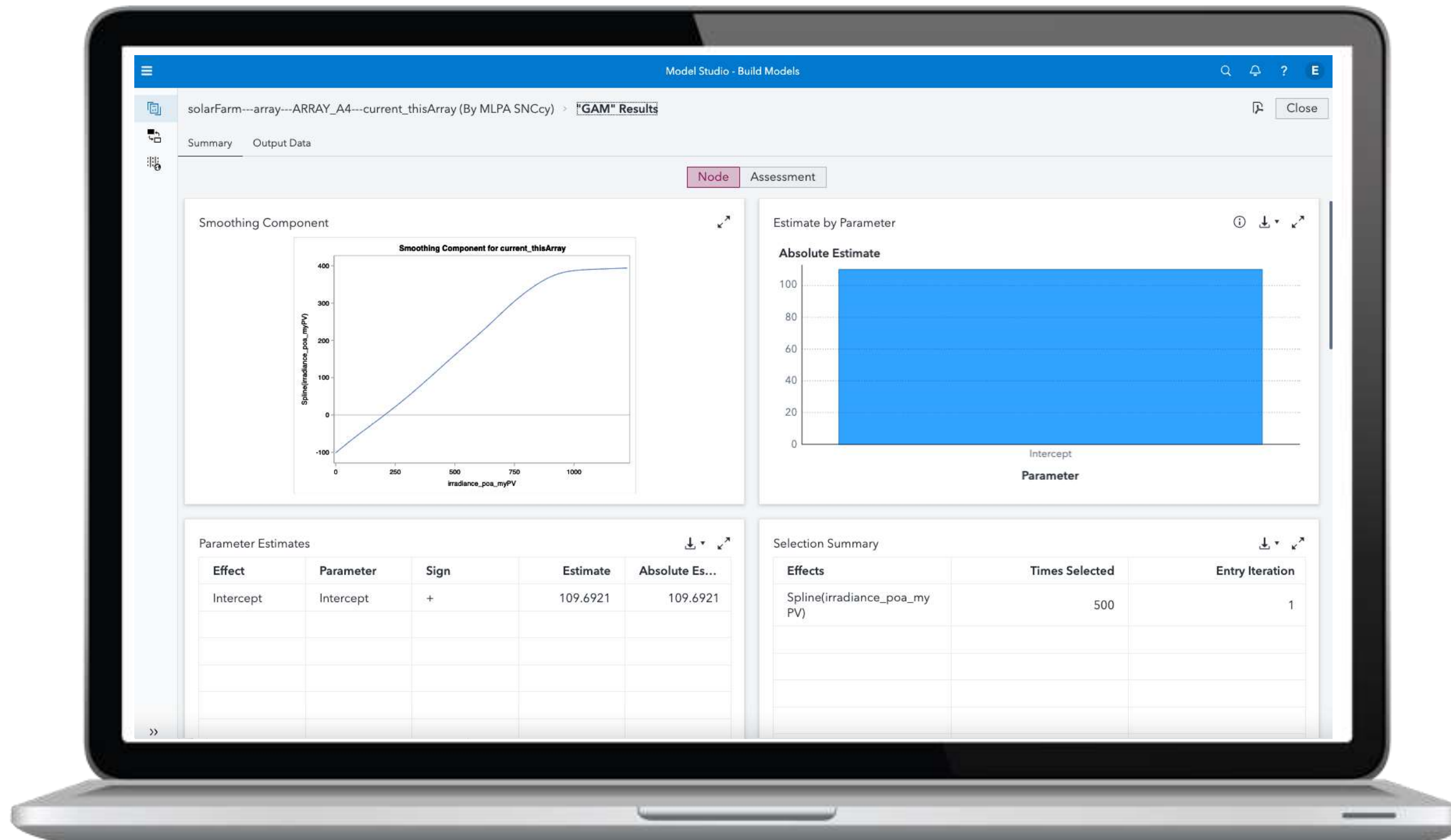


Register / Manage using
Model Manager



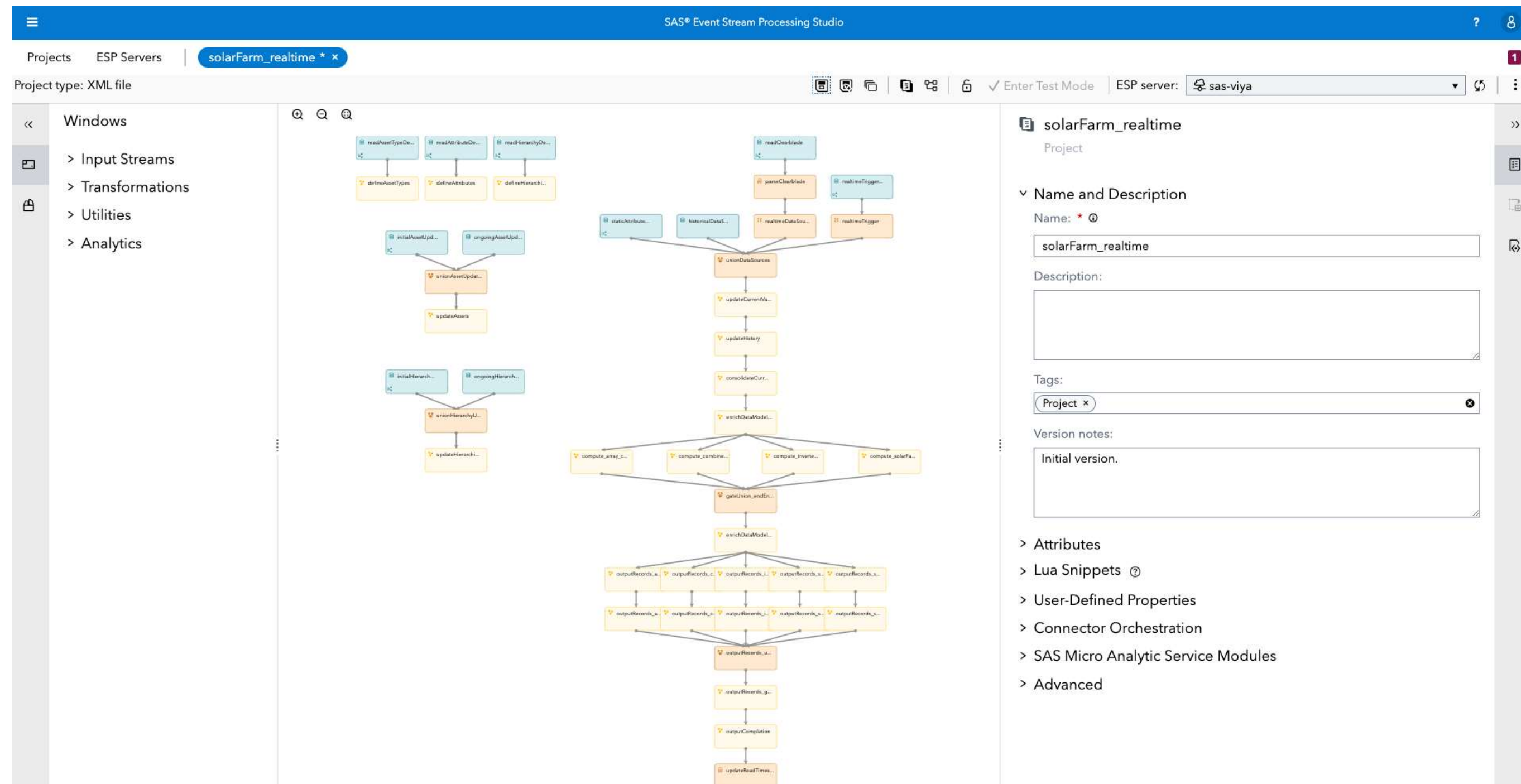
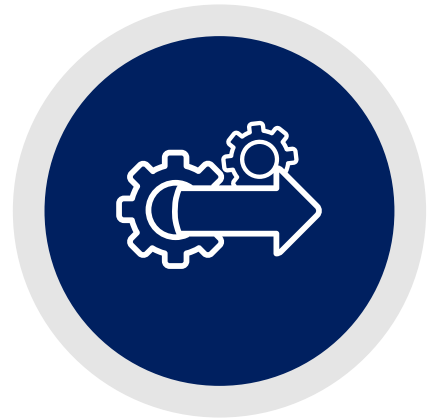
AutoML for IoT

Step 4 – Train ML Models and Register in Model Management



AutoML for IoT

Step 5 – Operationalize Streaming ML Models



Auto-generated SAS Event Streaming Processing Project

Result

ML Models Running Alongside Key Metrics and Settings



AutoML for IoT

Step 6 – Application Insights

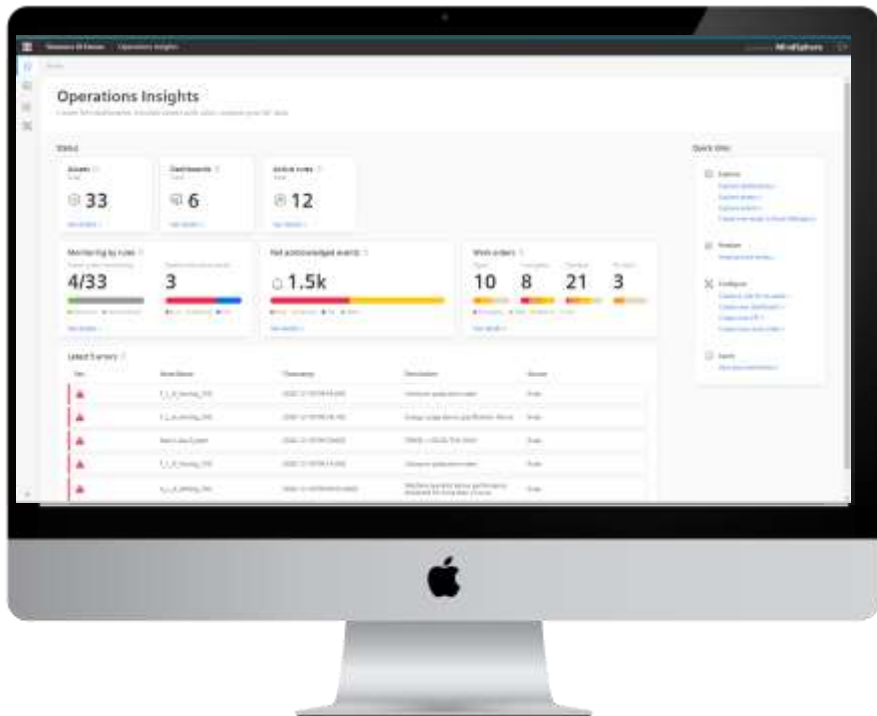
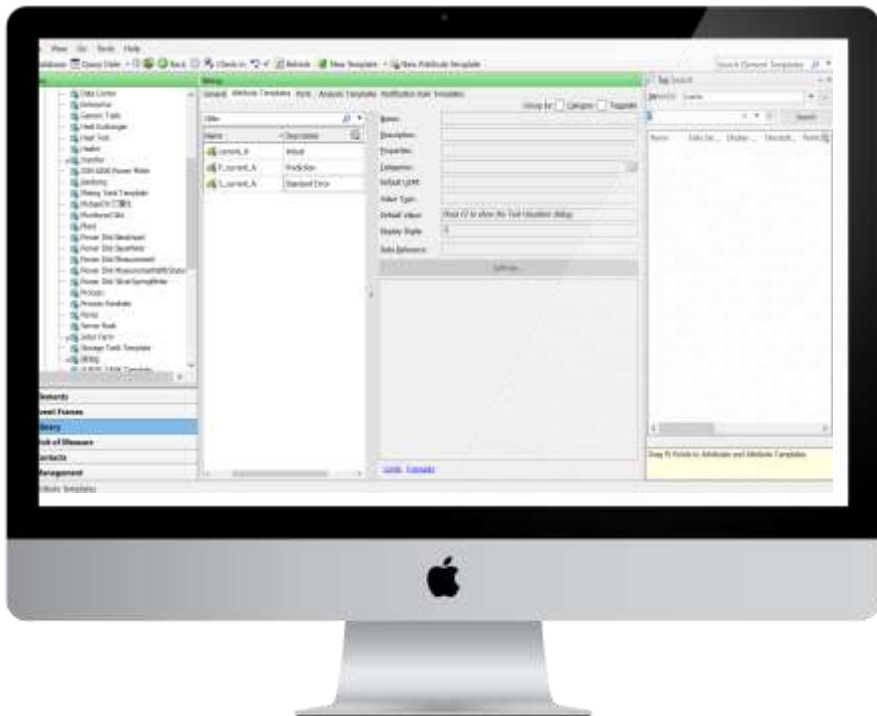
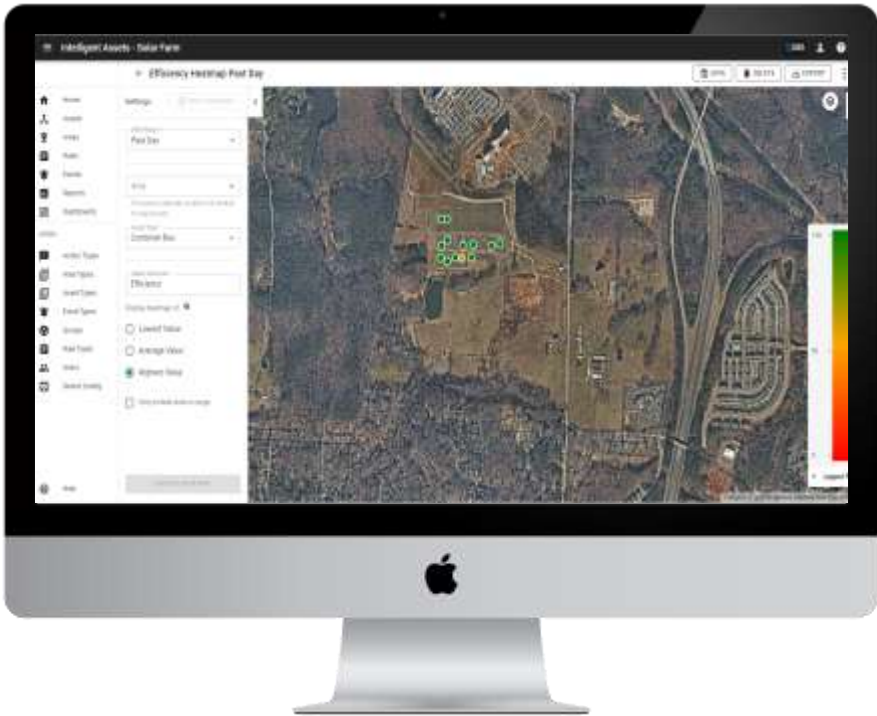


SAS Visual Analytics
Dashboards

ClearBlade Intelligent
Assets Dashboard

OSI PI Vision User
Interface

Siemens Operation
Insights Dashboard

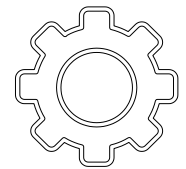


Flexible options to deploy streaming ML projects into
existing architectures (edge &/or cloud)

Translating to Industry

DEPCOM Power

DEPCOM designs, builds, and operates utility-scale solar power plants. They also offer energy storage solutions, maintenance services, and consulting services for the renewable energy industry



Key Challenges

As PV power plants continue to expand in size, it is critical to develop automated data processing tools to easily highlight operational impairments not efficiently identified by field personnel

Data efficiencies for reporting and analysis; currently very manual.

Need to move from reactive to proactive, eventually predictive.

Trustworthy KPI's & Advanced Analytics to enable performance guarantee success.

How SAS® supported the process

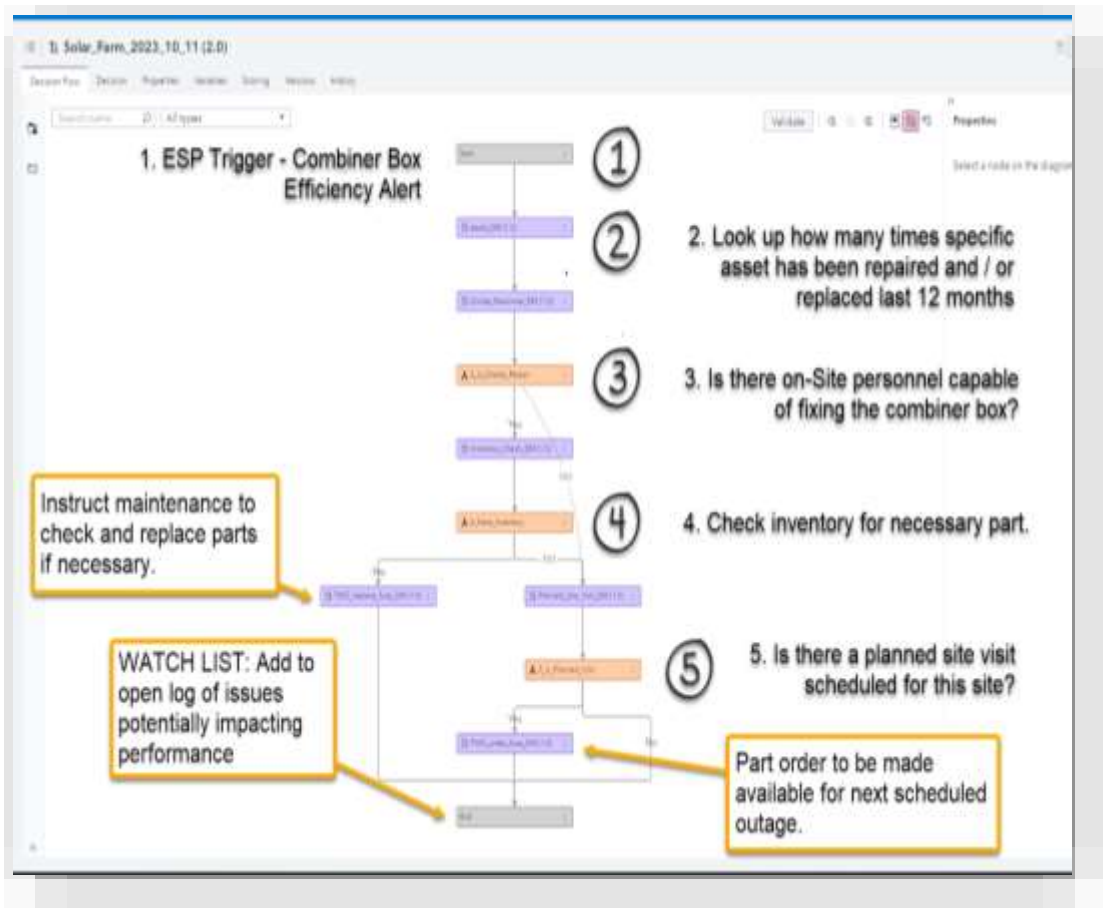
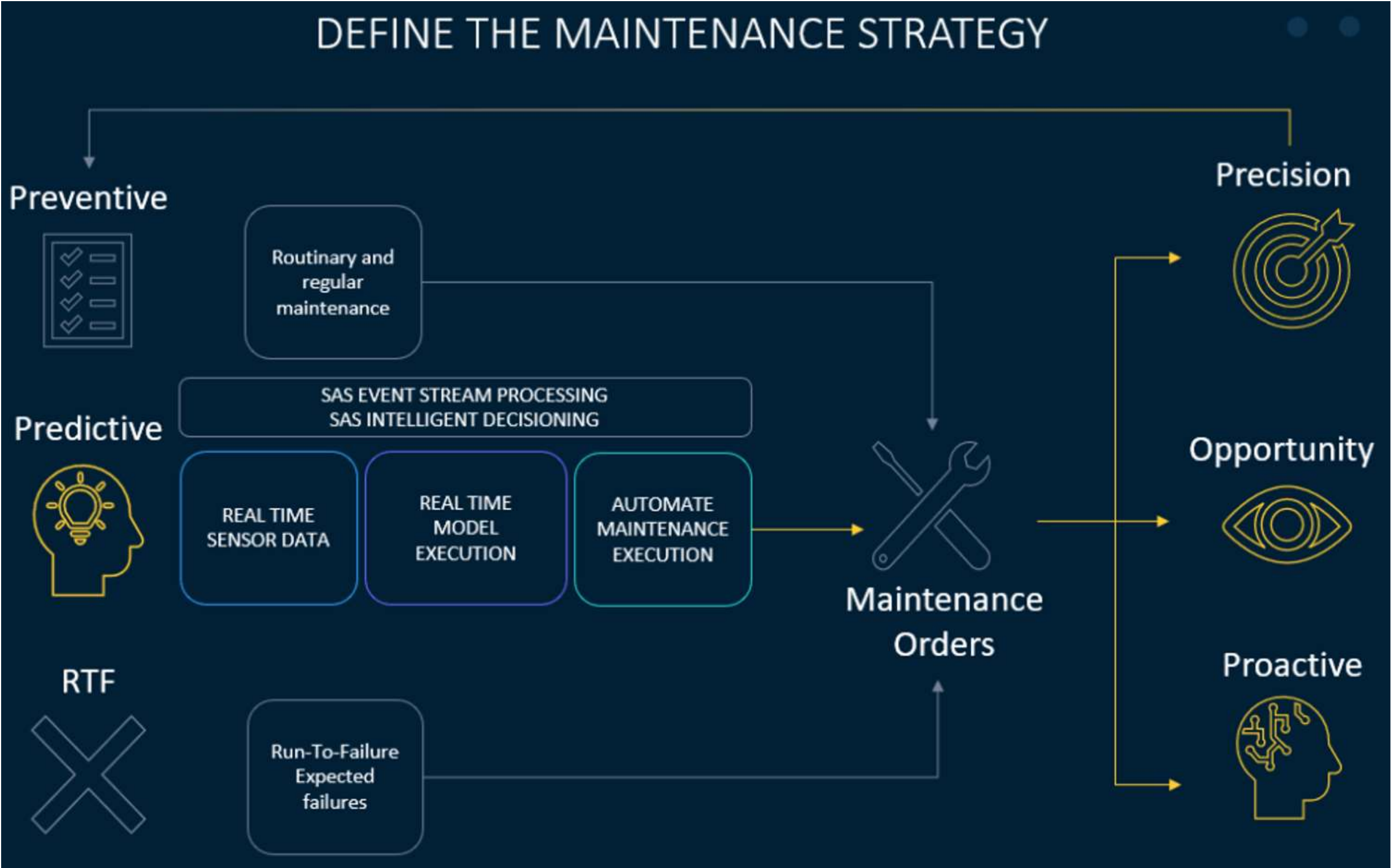


Expected Results

- Initial focus on DC Health of Large Utility Scale Solar Farms, ability to detect anomalies specifically to PV model and DC collection subsystems. (Combiner Box DC current data to flag underperforming combiner boxes to better guide field personnel to investigate and diagnose failures such as blown DC fuses and take corrective action
- Provide Operations Center proper digital tools to process increasingly large datasets to efficiently present actionable information.
- Future use cases include Spare Part/Inventory Strategy, Intelligent Decisioning, Next Generation Service offering w/Advanced analytics for DC Health, Ray Tracker Health, Plant Health

Future Directions

Solar Farm Maintenance Decisioning



Supporting Content

SAS Explore 2023 Session

Ultra-Agile Approach for the Deployment of Real-Time Analytics

